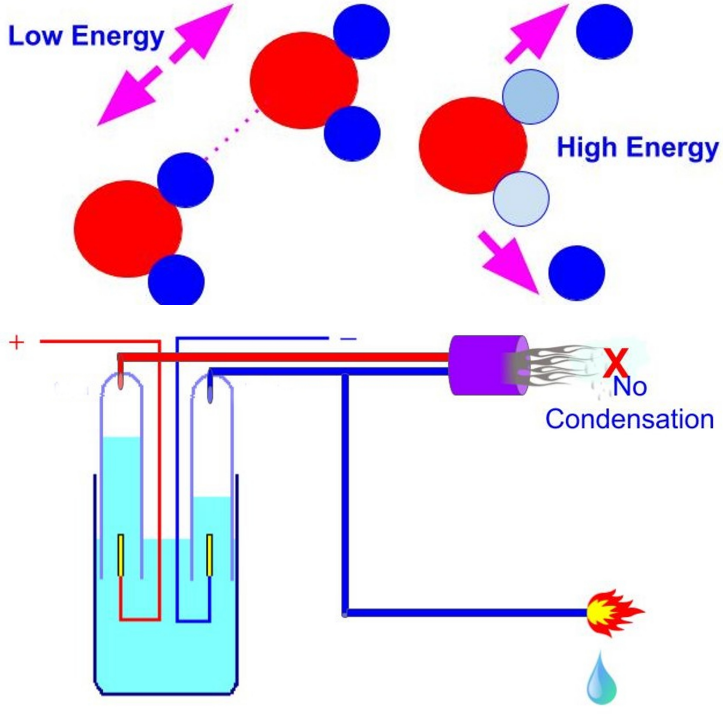
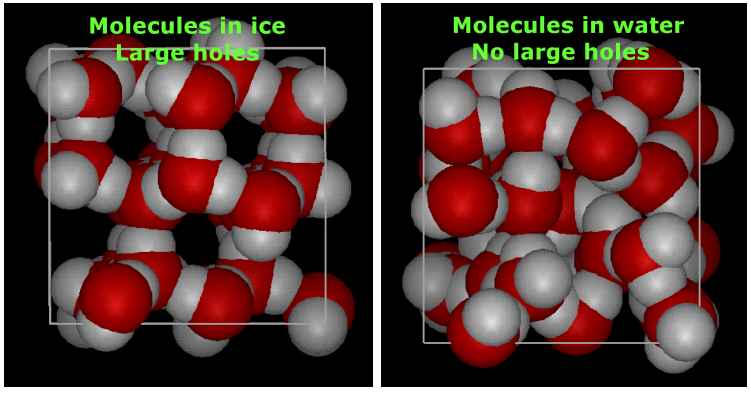
Water, water everywhere

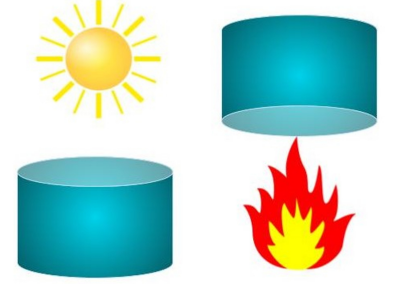


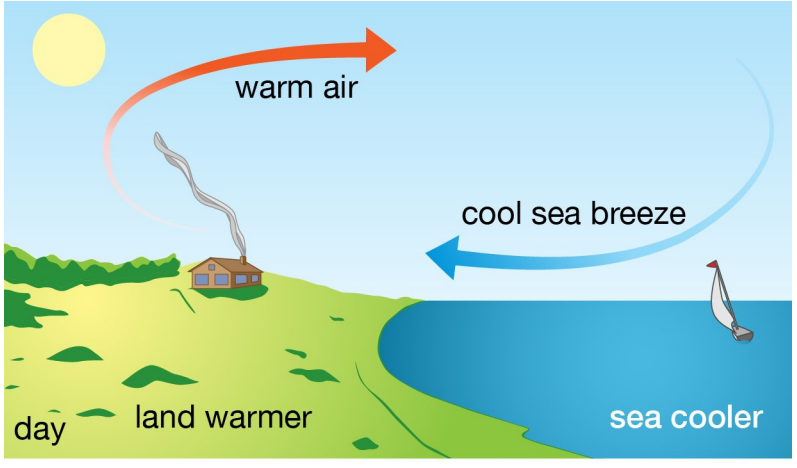
Water will become steam at 100°C but the water molecule will not break up into oxygen and hydrogen atoms till it is heated to a temperature higher than 1000°C. This difference shows that the bonds between the molecules in water are much weaker than those between the hydrogen and oxygen atoms within the molecule. It is not easy to heat steam to such high temperatures. So it is easier to decompose water into hydrogen and oxygen by passing electricity through it. The volume of hydrogen will be double the volume of oxygen, proving that a water molecule consists of two atoms of hydrogen and one of oxygen. {Picture left above} The hydrogen and oxygen produced will not immediately react to form water molecules even when they are mixed. Hydrogen has to be burnt to produce water. This is an example of the barrier to chemical reaction discussed earlier. The energy available in hydrogen and oxygen is more than that in a water molecule. So energy is released when hydrogen is burnt in oxygen. The energy released would help the other molecules to cross the barrier and so the reaction will continue. There could even be explosions while hydrogen is burning.

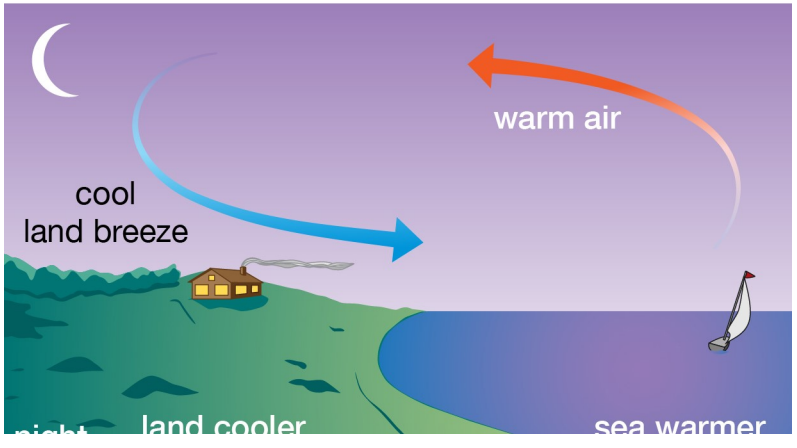


The bonds between water molecules in the liquid are called hydrogen bonds. Though a hydrogen bond is weaker than the bond between the hydrogen and oxygen atoms in the water molecule, these bonds play a major role in the natural world. It requires a lot of energy to heat water. For example, it will take five times more energy to increase the temperature of water than an equal weight of iron. Many chemicals dissolve in water but do not react with water. So they can easily be recovered from the solution. All these properties of water are due to the hydrogen bond. If water is cooled, below 0^{o}C, it turns into ice. The hydrogen bonds become stiff and big gaps are formed between the molecules. {Picture above} This makes ice lighter than water. Ice floats on water and so fish can survive in frozen lakes.

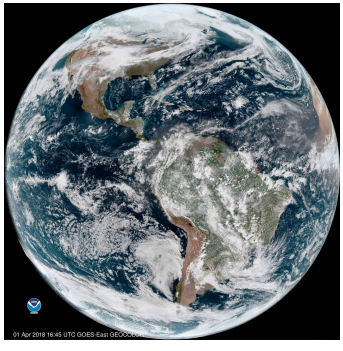
Metals allow heat energy to move rapidly. When one end of a metal rod is put in fire, the other end also gets very hot. Water and ice do not permit easy movement of heat energy. When water is heated from below, the heated water is lighter and moves to the top and carry heat energy along with it. When water is heated from above, the hot water stays on top. {Picture right}





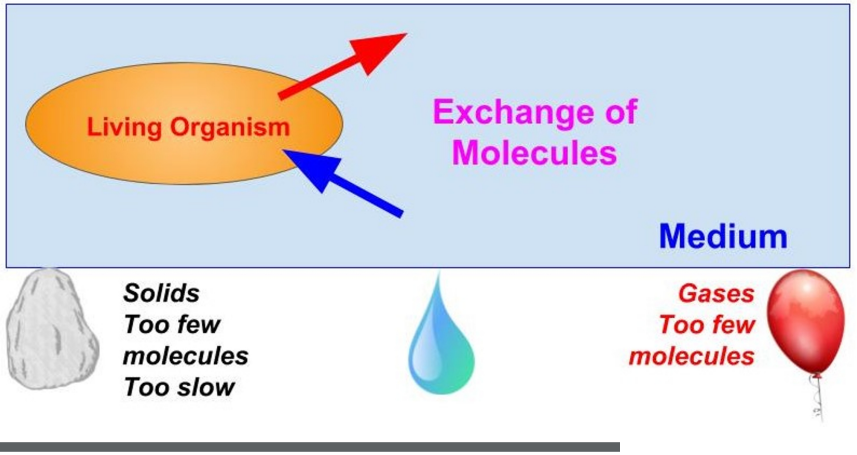


Wind flows from the sea onto the land during the day and from the land towards the sea during the night. Water on the surface of the sea is heated by the sun but the hot water stays at the top. Energy required to heat water is also much larger. So land gets hot before the sea does. The air on the land heats up and it rises. {Picture left top} So the cold air above the sea moves inland. But during night, the sea retains the heat absorbed during the day. So it cools slowly. The land cools much faster. The warmer air over the sea rises and the cooler air on the land moves towards the sea. {Picture left bottom} These are called the land and the sea breezes. Water in the sea also reduces the difference between the minimum and the maximum temperatures in coastal areas because the sea retains a large



quantity of heat. Thus, the average earth temperature is reduced because of the clouds and ice cover which will reflect sunlight back into space. {Picture left}. So the presence of water changes the weather in many ways.

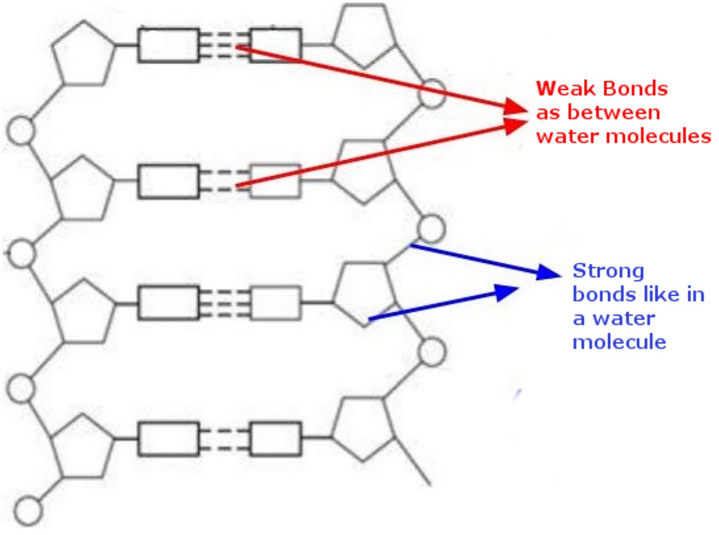
All living beings reproduce, they create a new generation. Non living things do not. To reproduce, every living being has to collect molecules from the surroundings and organize them in the form of a copy which has the ability to reproduce in it's turn. This process increases order but does not violate the first and second laws of thermodynamics. The living being acquires, from the surroundings, energy necessary to create this order also. {Picture right} Liquids clearly are the most suitable medium for a living being to exist. In a solid, the movement of molecules and atoms is very slow. In a gas, on the other hand, very few molecules are available. The living organisms can get a variety of molecules from the liquid medium and in large



numbers. Humans breathe air but depend on the movement of blood and other fluids inside the body for survival. More than sixty percent of a human body is actually water.

The molecules in the body themselves have to select molecules from outside and also how to organize them into the required order. The information required to perform this is in the form of molecules which are called the genes. When the new generation is created, using the information in the genes, a copy of the genes is also transferred to the new generation. In all living organisms, genes are a long molecule which is bound with a second identical strand. {Picture below right}

The bonds between the atoms in the two long molecules are quite strong, very much like the bonds between hydrogen and oxygen inside a water molecule. The two strands are attached to one another by hydrogen bonds just like the bonds between any two water molecules. So, the two strands can be separated without disturbing the bonds between atoms in the strands, that is to say without disturbing the genes. Each of the two separated strands contains all the information available to the living being. So, it is possible to make the second, attached to the two separated



strands and form double strands, one for each new generation. It is possible to separate the two strands without damaging the genes only if they are attached by hydrogen bonds.

We are not aware of any liquid other than water that could provide a variety of molecules for the living organism. We only know of only one planet where life exists, the earth. Scientists are continuously searching for the presence of life in other planets even though they do not have liquid water. But life is most unlikely without water and hydrogen bonds